Please enter the following new Title for the application:

Method for Treating the Surface of Metal Workpieces with Compressive and Tensile Stresses

Amendments to the Specification:

Please enter the following amendments to the Specification:

Please replace paragraphs 1 and 2 on pages 2-3 with the following amended paragraphs:

This object is achieved by surprisingly simple ways and means as set forth in the features of ~~claim 1~~ the present invention.

The configuration in accordance with the invention ~~of the method as set forth in the features of claim 1~~ in which the workpiece, for example, in the form of an elongated section, is worked at least in part by at least one roll provided at least in part with an outer profile such that the treated surface of the workpiece is exposed to inherent compressive stresses and the zones located beneath the treated surface of the workpiece is exposed to inherent tensile[[s]] stresses axially and tangentially, a particularly simple method is achieved for producing workpieces, such as elongated sections, or the bores and other openings thereof, e.g. through-holes and blind holes, at no high labor and cost expense with a substantially increased strength and/or hardness, extremely higher accuracy and smoothness. The method in accordance with the invention achieves cleaning the material surface and/or the zone near to the surface thereof of oxide crusts, for example, aluminum oxide crusts and detrimental soilage. During surface treatment surface defects are thus simultaneously eliminated to thus avoid crack propagation caused thereby. The result in all is that the workpieces are surrounded by an envelope several hundred microns thick identical in material which due to its enhanced material strength and the resulting inherent

compressive stress has a stiffening effect. The surface roughness is improved as compared to that of the workpieces directly after drawing or extruding by a factor of roughly 6 to 8 better, whereby roughness values of ra < 0.1 are the rule. The workpieces receive by consequence an inherent stress characteristic, namely inherent compressive stresses of the plastically deformed surface or near thereto and inherent tensile[[s]] stresses in the areas located beneath which act against each other. The workpieces receive consequently a considerably enhanced ultimate strength. As an additional advantage of the method in accordance with the invention due to a substantially reduced oxide film thickness an improved bonding is achieved with the result that the workpieces can be provided with galvanic coatings with no problem, ~~i,e~~ i.e., without the usual hydrogen embrittlement. Due to the improved bonding all and any systems of corrosion protection are just as possible. Due to such a surface treatment a consolidated surface structure cleaned of porous oxide particles is attained. The result in all of this partial surface treatment is that the material receives an inherent stress system resulting in a considerable enhanced ultimate strength.

Please replace paragraphs 1-4 on pages 3-4 with the following amended paragraphs:

Advantageous design aspects of the method in accordance with the invention are described in ~~the claims 2 to 18~~ further embodiments.

Of major significance for an additional simplification in surface treatment of the workpiece are the features as set forth in a further embodiment ~~claim 2~~, by which the workpiece is moved in the axial direction by the at least one roll provided at least in part with an outer profile which eliminates the need for any separate means technically by the method for advancing the workpiece after surface treatment.

In another embodiment, to ~~To~~ further enhance the strength and hardness whilst improving the accuracy the workpiece ~~in the special aspect of the invention as set forth in claim 3~~ is worked by at least one, more particularly two roll(s) provided at least in part with an outer profile in sequence in the opposite direction. In this way the surface of the workpiece to be treated is worked preferably transversely to the direction of movement of the workpiece first in one direction and then in the direction opposite thereto.

Of extreme significance for surface treatment of a workpiece having a round surface, for example, a round or tubular material, are the features of another embodiment ~~claim 4~~ by which the workpiece is worked by at least one roll provided at least in part with an outer profile arranged parallel to the workpiece and which is rotatable about the longitudinal centerline as well as about the workpiece.

Please replace paragraphs 1-4 on page 4 with the following amended paragraphs:

Of great interest for surface treatment of a workpiece including at least one bore or similar opening or the bore opening itself are the features .as set forth in an embodiment ~~claim 5~~ by which the workpiece is worked by at least one roll provided at least in part with an outer profile arranged parallel to the bore or similar opening and which is rotatable about the longitudinal centerline as well as about the bore or similar opening.

It is further within the scope of the invention that the workpiece or its surface in the form of an outer-located surface area and/or an inner-located surface area, for example, the inner wall of a bore, ~~as set forth in claim 6,~~ is worked by a roll provided at least in part with an outer profile and at least one, more particularly substantially non-profiled roll(s) arranged about the workpiece or in the at least one bore or similar opening.

~~As set forth in claim 7 it is~~ It is also provided for in this context that the workpiece is worked by a roll having an outer profile in the form of annular beads and recesses arranged at an angle a and/or to the longitudinal centerline of the roll, whereby the annular beads and recesses arranged at an angle and/or to the longitudinal centerline of the roll comprise a lead position substantially opposing each other.

In another aspect of the method in accordance with the invention ~~as set forth in claim 8~~ the workpiece is worked by two rolls each provided at least in part with an outer profile and a substantially non-profiled roll arranged about the workpiece, more particularly equispaced from each other.

Please replace paragraphs 1-6 on pages 5-6 with the following amended paragraphs:

Preferably the workpiece or the surface area thereof to be treated is worked ~~as set forth in claim 9~~ by two rolls having an outer profile in the form of annular beads and recesses arranged at an angle α or α' to the longitudinal centerlines of the rolls.

In this context the two rolls ~~as set forth in claim 10~~ are preferably powered in the same direction of rotation when the annular beads and recesses arranged at an angle α or α' to the longitudinal centerlines of the two rolls comprise a lead position substantially opposing each other.

As an alternative thereto the rolls ~~as set forth in claim 11~~ are powered in the opposite direction of rotation when the annular beads and recesses arranged at an angle α or α' to the longitudinal centerlines of the two rolls comprise a lead position substantially the same to each other.

In yet another aspect of the invention for surface treatment of a workpiece including at least one flat surface it is particularly of advantage ~~as set forth in claim 12~~ that the workpiece is worked by

at least one roll provided at least in part with an outer profile arranged substantially perpendicular or at an angle β to the workpiece and rotatable about the longitudinal centerline thereof.

Expediently the workpiece ~~in accordance with the means as set forth in claim 13~~ is worked by at least one roll provided at least in part with an outer profile and is worked or supported by at least one further roll provided at least in part with an outer profile or a non-profiled roll or similar supporting means located spaced away and opposite the at least one roll.

Yet another aspect of the method in accordance with the invention involves working the surface to be treated of the workpiece ~~as set forth in 14~~ by the at least one roll including an outer profile in the form of annular beads and recesses.

Please replace paragraphs 1-4 on pages 6-7 with the following amended paragraphs:

It is furthermore within the scope of the invention to work the surface of the workpiece to be treated ~~as set forth in claim 15~~ by several rolls having an outer profile in the form of annular beads and recesses, whereby the annular beads and recesses of adjoining rolls differ from each other in their configuration and arrangement and/or each of the adjoining rolls is powered in a different direction of rotation.

In this arrangement ~~as set forth in claim 16~~ it is provided for in accordance with the invention that the workpiece or the surface area of the workpiece to be treated is worked by rolls having an outer profile in the form of beads and recesses arranged at an angle α or α' to the longitudinal centerlines of the rolls, whereby the rolls are powered in the same direction of rotation for a substantially opposite lead position of the beads and recesses or in the opposite direction of rotation for a substantially same lead position of the beads and recesses.

As an alternative or in addition thereto it is provided for in accordance with the invention that the workpiece or the surface area of the workpiece to be treated ~~as set forth in claim 17~~ is worked by rolls having an outer profile in the form of annular beads and recesses arranged perpendicular to their longitudinal centerline, more particularly axially staggered relatively to each other.

Of particularly great significance are in conclusion the features ~~as set forth in claim 18~~ by which the workpiece to be treated or the surface to be treated at least in part or the at least one bore or similar opening to be treated of the workpiece is coated with a covering of metal, such as chromium, copper or the like, and/or with a metal alloy and/or a paint and/or plastics and/or is anodized and/or galvanized and/or pickled. By means of the invention considerably improved bonding properties of the treated workpieces are achievable. This in turn produces quite generally substantial improvements as regards coating the workpieces, it thus being possible, for example, to coat a elongated section, such as a wire, having a core of aluminum with a (closed or continuous) shell of copper. The copper coating remains bonded to the core of aluminum extremely durably and particularly resistant to abrasion. Making use of copper wires of solid material is now no longer necessary. In addition to weight-savings this thus achieves particularly considerable cost-savings. Likewise possible by the method in accordance with the invention are high-load hard chromium coatings or the like without cost-intensive preparatory work, it now being possible, for example, to totally eliminate complicated and time-intensive stripping of the near-surface oxide films and/or soilage prior to chromium-plating workpieces such as brass shafts and the like, as hitherto necessary. Now likewise possible is a coating resistant to abrasion of, for example, anodizing paints or anodizing or galvanizing of workpieces.

Please delete paragraph 2 on page 7 which starts with "This object is achieved by suprisingly".

Please replace paragraphs 1-3 on pages 8-9 with the following amended paragraphs:

In accordance ~~therewith~~ with another embodiment the device in accordance with the invention for the surface treatment of workpieces, for example, of elongated sections, having a round surface, comprises three rolls arranged parallel to and about the workpiece, more particularly equispaced from each other, provided at least in part with an outer profile working the surface of the workpiece and each rotatable about their longitudinal centerlines as well as in conclusion about the workpiece. The device in accordance with the invention is thus characterized by a particularly simple and compact design. In addition the device in accordance with the invention assures a extremely high production accuracy in the production of workpieces have especially high strength and hardness as well as with high accuracy. Thus, workpieces, for example, in the form of elongated sections, can be produced with accuracy of for example, up to at least approximately 1/10 rpm. In addition the device in accordance with the invention subjects the workpieces, for example, in the form of elongated sections, to a surface treatment involving no rotary movement, thus enabling feed speeds of up to approximately 100 mpm, for example, to be attained for such workpieces having a round surface. Last but not least, it is due to an extremely high working speed that the device in accordance with the invention achieves a substantial reduction in the labor and costs involved in the surface treatment of such workpieces having a round surface.

~~This object is further achieved as regards the device by surprisingly simple features as set forth in claim 20.~~

In a further embodiment ~~In accordance therewith~~ a device for surface treatment is provided suitable for correspondingly working workpieces or their bores or similar openings such a through-holes and/or blind holes just as well, more particularly for implementing the method as set forth above ~~in any of the preceding claims~~, comprising at least two, more particularly three

rolls arranged in parallel and in the bore or similar opening which are provided at least in part with an outer profile working the bore or similar opening and each rotatable individually about their longitudinal centerlines as well as in combination in the bore or similar opening. In addition to the advantages as cited above it is just as possible in this way to fixedly clamp in place the workpieces to be surface treated, where necessary.

Please replace paragraphs 1-6 on pages 9-10 with the following amended paragraphs:

Advantageous design details of the device in accordance with the invention are described ~~in the claims 21 to 37~~ below.

Of major importance for surface treatment of workpieces are the features ~~of claims 21 and 22~~ by which a roll, more particularly two rolls is/are provided at least in part with an outer profile working the workpiece and the remaining rolls, more particularly one roll, are/is configured non-profiled.

As set forth in ~~claim 23~~ another embodiment the outer profile of the at least one roll working the workpiece or its surface and/or bores is configured in the form of annular beads and recesses arranged at an angle α and/or α' to the longitudinal centerline of the roll.

~~Due to the features of claims 24 to 26 it~~ It is possible to ~~advantage~~ to work the surface of the workpiece by the outer profile of the at least one, more particularly two rolls in sequence in the opposite direction, i.e. by dual shaping substantially approximately transversely to or also inclined to the direction of movement of the workpiece.

It is furthermore within the scope of the invention to provide the at least one roll ~~as set forth in claim 27~~ with non-profiled ends.

In this arrangement the non-profiled end of the at least one roll ~~as set forth in claim 28~~ incoming in the direction of movement of the workpiece comprises a slightly smaller outer diameter to compensate any irregularities of the workpiece or to undertake a certain straightening function.

Please replace paragraphs 1-4 on page 10 with the following amended paragraphs:

In accordance with the features of ~~claim 29~~ another embodiment the non-profiled end of the at least one roll outgoing in the direction of movement of the workpiece has by contrast a slightly larger outer diameter to bring the already surface treatment workpiece to a constant dimension with a smooth surface.

It is furthermore within the scope of the invention that the rolls ~~as set forth in claims 30 and 31~~ are mounted by a drive means for rotating each of the rolls individually about their longitudinal centerlines and a drive head for rotating the rolls in combination about the workpiece.

The means ~~afforded by claim 32, namely~~ of controlling the drive means and/or the drive head hydraulically or pneumatically permit infinitely variable control in avoiding all and any slip and thus as a result an extremely high surface smoothness of the workpiece. This also permits extremely precise influencing the feed rate of the workpiece in taking into account the characteristical features and operating conditions, such as diameter of the rolls, pitch of the annular beads and recesses, workpiece diameter and many other things.

In this context powering the rolls and a worm drive of the drive head ~~as set forth in claims 33 and 34~~ is expediently undertaken via separate drive motors which are especially suitable for hydraulic or pneumatic control. This aspect additional promotes precise control of the device in accordance with the invention so that the movement of the rolls and worm drive can be influenced individually in each case.

Please replace paragraphs 2-5 on pages 11-12 with the following amended paragraphs:

The features of ~~claims 35 and 36~~ other embodiments serve in a further aspect of the invention an extremely high versatility of the device since due to the movement of the drive means and drive head relative to each other a lengthwise compensation of rolls differing in length and thus optional interchangeability of the rolls is made possible.

Achieving an extremely high accuracy or only very small tolerances whilst permitting a high feed rate is further the object of ~~the features of claim 37,~~ an embodiment by which the drive means and/or the drive head is/are provided with a centering means for the workpiece to thus eliminate or at least reduce any vibrations occurring due to the surface treatment in the region of the rolls.

~~This object is achieved surprisingly simple by the device features as set forth in claim 38.~~

In ~~accordance therewith~~ a further embodiment the device in accordance with the invention for surface treatment of workpieces, preferably with elongated sections having at least one flat surface, comprises at least one roll arranged substantially perpendicular or at an angle to the longitudinal direction of the workpiece which is provided with an outer profile working the surface of the workpiece at least in part and which is rotatable about the longitudinal centerline thereof. The device in accordance with the invention is thus suitable particularly for surface treatment of workpieces having an approximately rectangular, for example square, cross-section. The advantages achievable with such a device are substantially identical to the advantages as cited above in conjunction with the embodiment of a device for surface treatment of workpieces having a round surface, such as simple design, production of workpieces with particularly high strength and hardness as well as high accuracy, low labor and cost expense, etc.

Please replace paragraphs 1-4 on pages 12-13 with the following amended paragraphs:

Expediently, the at least one roll provided with an outer profile at least in part ~~as set forth in claim 39~~ is assigned at least one further roll provided at least in part with an outer profile or non-profiled, roll or the same supporting means opposite to provide a so-called counter-bearing for the at least one roll. If not only the upper surface of the workpiece is to be treated by the at least one roll, but also the lower surface at the same time, at least one further roll is provided comprising an outer profile. Otherwise a non-profiled roll or similar supporting means, for example, in the form of a supporting plate etc may be employed.

Of major importance for the surface treatment are the features ~~of claims 40 to 42~~ by namely the at least one roll comprising an outer profile having the form of annular beads and recesses at an angle α or α' to the longitudinal centerline of the roll in each case.

In another embodiment, to ~~To~~ further enhance the strength and hardness whilst improving the accuracy ~~the aspects as set forth in claim 43 are of extremely high importance. In accordance therewith~~ the at least one roll provided with an outer profile at least in part is followed by an additional roll provided likewise at least in part with an outer profile to work the surface of the workpiece in the direction of movement of the workpiece in sequence in the opposite direction, i.e. in shaping it approximately transversely or inclined to the direction of movement of workpiece in a single reciprocating movement.

Such a more or less reciprocating shaping of the surface of the workpiece is achievable to advantage ~~by the features of claims 44 and 45~~ as a function of design configuration, arrangement and direction of rotation of the beads and recesses of the outer profile

Please replace paragraphs 1-5 on page 13 with the following amended paragraphs:

It is within the scope of the invention to provide upstream and/or downstream of the at least one roll provided at least in part with an outer profile working the surface of the workpiece ~~as set forth in claim 46~~ at least one non-profiled roll in the direction of movement of the workpiece.

In accordance with the aspect of the device in accordance with the invention ~~as set forth in claim 47~~ the at least one upstream non-profiled roll comprises a slightly smaller outer diameter to feed the workpiece evenly to the outer profile and to thereby compensate or at least to mitigate any existing irregularities and undesirable out-of-tolerance, the one upstream non-profiled roll thus serving a certain straightening function.

To bring the workpiece coming from the region of the outer profile to a predefined constant dimension with a smooth surface, the at least one non-profiled downstream roll ~~as set forth in claim 48~~ comprises a slightly larger outer diameter. The at least one downstream, non-profiled roll can thus be put to use for additional shaping.

It is furthermore within the scope of the invention that the annular beads ~~as set forth in claim 49~~ protrude beyond the outer diameter of the at least one roll.

The features of ~~claims 50 to 52~~ alternate embodiments serve surface treatment of workpieces of optional thickness, as compared to which the at least one roll is mounted in a mounting means movable relative to supporting means supporting the workpiece, for example, in the form of at least one further roll. The versatility of the device in accordance with the invention is enhanced thereby since workpieces of optional thickness and height dimension can be surface treated.

Please replace paragraphs 1-5 on pages 14-15 with the following amended paragraphs:

As set forth in ~~claim 53~~ another embodiment the mounting means and/or the supporting means is/are expediently hydraulically or pneumatically controllable.

By the features of ~~claim 54~~ another embodiment, the at least one (further) roll is assigned in each case a separate drive motor in expediently achieving individual control of each roll.

It is furthermore within the scope of the invention that the rolls ~~as set forth in claim 55~~ are configured multi-part, they more particularly for example, being composed of a roll of high toughness and an envelope of high strength or hardness and thus hardwearing.

In a further aspect of the invention the rolls ~~as set forth in claim 56~~ are coolable by an internal cooling system and/or an external cooling bath as a result of which the useful life of the device can be enhanced.

By means of the method and the corresponding devices in accordance with the invention it is in conclusion ~~as set forth in claim 57~~ further possible to produce workpieces of metal, more particularly base metals such as for example, aluminum, lead, chromium, iron, cobalt, nickel, copper, manganese, molybdenum, silicon, tungsten, tin, ~~zink~~ zinc or alloys thereof such as brass or of noble metals such as gold, palladium, platinum, silver or alloys thereof, or of combinations of base and noble metals. Preferred are steel and/or aluminum and/or alloyed aluminum such as for example, $AlMg_{4.5}Mn$, $AlMgSi_{0.5}$, AlMgSi, $AlMg_5$, $AlZn_{4.5}Mg$, AlCuMg, $AlCuMg_2$, $AlZnMgCu_{0.5}$, $AlZnMgCu_{1.5}$, AlCuMgPb or of noble metals such as gold, palladium, platinum, silver or alloys thereof, or of combinations of base and noble metals. Workpieces of for example, aluminum or alloys thereof have proven to be particularly suitable due to their various advantageous properties such as corrosion-resistance, low specific density, etc. It is particularly

in the field of automotive engineering that these materials are finding ever-increasing application. The disadvantages associated with these materials such as for example, hitherto inadequate strength, labor- and cost- intensive pre- and after-treatment of the material surface due to existing oxide films and (longitudinal) cracks as well as extremely large tolerances etc can now be eliminated by the method and the associated devices in accordance with the invention by extremely simple ways and means.

Please replace paragraphs 1-4 on page 15 with the following amended paragraphs:

Thus elongated sections of solid material, especially where hardened and/or coated, more particularly wires, rods and elongated and/or tubular material, more particularly tubing, preferably headrest brackets in automobiles can now be produced as set forth in ~~claim 58~~ another embodiment.

As set forth in ~~claim 59~~ a further embodiment the method and the device in accordance with the invention can also be put to use in the production of coiled, more particularly hardened and/or coated workpieces preferably coiled springs.

Expediently the method and the device in accordance with the invention are ~~suitable as set forth in claim 58~~ likewise for the production of bores or similar openings, more particularly through-holes and/or blind holes in automotive engines.

Possible applications hitherto not available for aluminum or alloys thereof are now opened up due to the considerable enhanced strength and hardness, improved ultimate strength, low tolerances and high smoothness as well as an enhanced bonding of galvanized coatings or other materials designed to prevent corrosion and oxidation[[.]], as a result of which the versatility of the aluminum or alloys thereof and their long- since accepted advantages are further enhanced.